Arctic marine primary production in respect to changes in sea ice cover.

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Abstract – This study provides up-to-date information on the primary production (PPR) changes in the Arctic. PPR values retrieved from different sensors data (MERIS, MODIS, SeaWiFS) are taken into account. The impact of factors, driving primary production change in the Arctic is estimated by comparing PPR values to sea ice, wind speed, sea surface temperature (SST), chlorophyll-a (CHL) and Photosynthetically Active Radiation (PAR) satellite data. Results will be validated by Polarstern Cruise ARK XXV (June-July 2010), as well as by AWI, PANGAEA, NASA SeaBASS in-situ data.

Keywords:
primary production modeling, satellite data validation.

1. INTRODUCTION

The influence of the rapid changes in sea ice coverage on Arctic marine primary production has not been studied so far due to the lack of sufficient in-situ measurements and gaps in satellite data in high latitudes.

To study this in more detail we want to investigate the interaction between the changing sea ice coverage, other physical parameters (e.g. sea surface temperature, wind field/ocean currents) and phytoplankton biomass and primary production in the Arctic Ocean by using in-situ, remote sensing and modeling techniques.

2. DATA AND METHODS

Primary production (PPR) maps, representing PPR averaged for every month of the years 2002-2007, were obtained using the Vertically Generalized Primary production Model by Behrenfeld and Falkowski(1997) (VGPM). The standard VGPM primary production dataset of Oregon State University is based on MODIS CHL, MODIS SST and SeaWiFS PAR data. It does not fully cover the years after 2007 due to the problems with SeaWiFS data delivery. For this reason it was supplemented by the dataset from the sensor MERIS on ENVISAT. Additional CHL and PPR data was taken from GlobColour web-site, the European service for ocean color data. GlobColour primary production, as compared to the standard VGPM PPR dataset, should give more reliable results since it is based on the 3-sensor merged MERIS-MODIS-SeaWiFS chlorophyll-a data. Unfortunately GlobColour PPR is a demonstration product available for just one particular year (2003) and therefore was taken only for a comparison. The differences between standard VGPM PPR (Figure 1) and GlobColour PPR (Figure 2) in July 2003 can be seen in the figures.

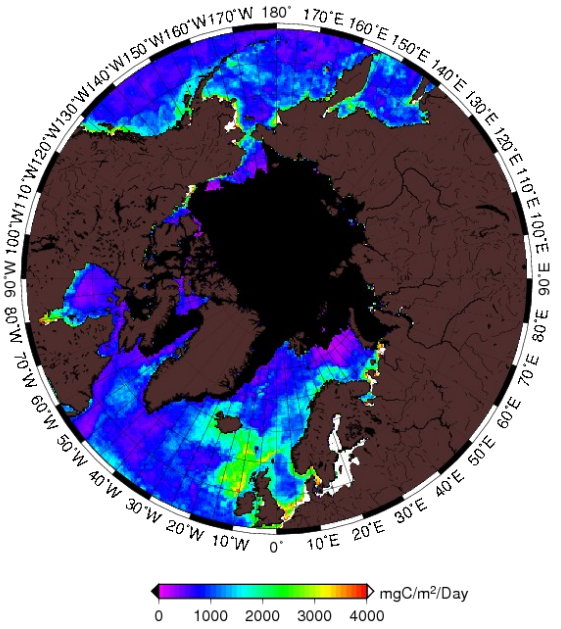

Figure 1. July 2003 primary production, grid spacing 1/6°, VGPM with SeaWiFS PAR, MODIS SST and CHL as input parameters.

To investigate the various factors influencing primary production variability in the Arctic, data of sea surface temperature (MODIS), wind speed (ECMWF reanalysis data), sea ice cover (PHAROS group of University of Bremen), chlorophyll-a (merged GlobColour MERIS-MODIS-SeaWiFS) and PAR (SeaWiFS) were used to produce maps with the same time averaging as PPR maps and then analyzed in respect to primary production variability.

Our results were compared to the studies of Arrigo et al. (2008) and Pabi et al. (2008). Arrigo et al. (2008) and Pabi et al. (2008) also studied the PPR variability in the Arctic,

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but with different input data and a different primary production model.

VGPM is a global model and therefore may have errors in output for not taking into account regional features of the Arctic waters. The next step of our work is to obtain the parameters that depend on the vertical structure of the waters and strongly vary regionally (such as z_{eu} – depth of the euphotic layer) not from the satellite (which is the standard approach), but from in situ measurements.

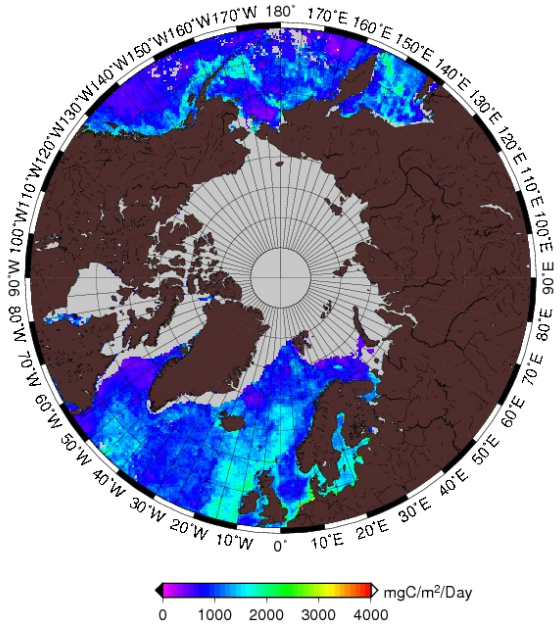

Figure 2. July 2003 primary production, grid spacing 1/12°, GlobColour product with MERIS PAR and merged MERIS-MODIS-SeaWiFS CHL as input parameters.

Chlorophyll-a and primary production values are then planned to be compared to those obtained from the coupled ocean-ice-ecosystem model by Losch et al. (2008) to give suggestions for improving this model for the application to the Arctic Ocean. Results of the comparison shall determine whether the model spatial resolution is sufficient to capture the variability observed by satellite (i.e. the most comprehensive validation data currently available). Spatial patchiness in the satellite data will be assessed and compared with the range in model data at all available resolutions.

3. VALIDATION OF RESULTS .

The available in situ primary production data from the Arctic are not enough for judging the quality of our PPR estimates.
Therefore, results will be validated by the primary production modeled from available bio-optical and oceanographic in-situ data. For this purpose we plan to use the same model as in the case of satellite data (VGPM) and input in situ data from AWI, PANGAEA and NASA SeaBASS archives. However, it is a challenge to find all the parameters required to construct PPR using VGPM (CHL, PAR, SST and z_{eu} parameters) taken at the same time and place. This motivated us to additionally collect all data needed during the ARK XXV Polarstern cruise (June-July 2010).

4. CONCLUSION.

In our study we have analyzed both standard (Oregon State University VGPM) and present-day (GlobColour merged MERIS-MODIS-SeaWiFS) primary production datasets. The influence of oceanographic and bio-optical factors on primary production variability was studied by comparing PPR datasets to the ones of sea surface temperature (MODIS), wind speed (ECMWF reanalysis data), sea ice cover (PHAROS group of University of Bremen), chlorophyll-a (merged GlobColour MERIS-MODIS-SeaWiFS) and PAR (SeaWiFS). Results were compared to Arrigo et al. (2008) and Pabi et al. (2008) which refer to similar subject.
Our future plans are to use in-situ datasets in order to not only validate PPR estimates, but as well account for regional Arctic features in the global VGPM model. The final results will be used to improve the coupled ocean-ice-ecosystem model by Losch et al.

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